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Conversion of IRAMMP Data to HDF Format

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CONVERSION OF IRAMMP DATA TO HDF FORMAT

I. Introduction

In the last few years a public-domain standard format for the storage of scientific data, images, and auxiliary information has gained popular acceptance [1]. This format, developed at NCSA - University of Illinois, is called Hierarchical Data Format (HDF). The HDF format is an attractive alternative to the NATO format for the storage of IRAMMP data for two reasons. First, HDF allows a convenient means for storage of auxiliary data in the same file as the basic image data. In the case of IRAMMP this includes the time stamp information in addition to general information such as filter setting, date, laboratory, etc. Second, a variety of powerful public-domain and commercial data visualization software packages can read and manipulate HDF files. The public-domain packages include the NCSA developed XImage and XDS. A commercial firm has developed value-added versions of these programs for a variety of popular hardware platforms including Macintosh and UNIX workstations. Modules allowing most data visualization software packages to read HDF files exist or will soon be available. The HDF standard is currently under consideration by the National Science Foundation (NSF) for possible merger with the netCDF data format. The netCDF format is itself based on a NASA format called CDF. This development makes it likely that HDF format files will become accessible to an increasingly wide range of application software packages.

It is the purpose of this report to describe the implementation of HDF for IRAMMP data developed at the Naval Research Laboratory. The report also provides information on how to acquire the public-domain programs XImage and XDS from NCSA via the Internet.

II. IRAMMP Data - existing NATO format

The current distribution format for IRAMMP data uses the NATO format. This is an older standard format developed to allow interchange of data among the various NATO technical working groups. The chief virtue of the NATO format is that it is a

machine independent, nine track tape compatible, standard data format. It is not ideally suited to the newer computing environment characterized by workstations running sophisticated graphical user interfaces and data visualization software packages. To provide background for the HDF implementation, this section reviews the manner in which IRAMMP data is stored using the NATO format.

The IRAMMP sensor is a 120 detector scanner. Images are thus 120 rows by M columns. Each column represents a time sample. The sensor is usually operated in such a manner as to produce $M = 1455$ samples per image. Actually, the IRAMMP sensor simultaneously records both longwave IR (LWIR) and midwave IR (MWIR) images. However, these two images are recorded separately. Consequently this detail is not germane to the subject of this report. The image specific value of M is recorded in a header to be described below. The NATO format files that are distributed to the general user community contain calibrated data. The units associated with each data value are banded radiance (watt/sqm/sr).

The NATO format IRAMMP files are organized as a sequence of 256 byte records. The images are stored sequentially with each image comprising the same record structure. This structure is: 1) a single record standard format NATO header containing such information as the date on which the data was recorded and the integer M, 2) a two record IRAMMP header containing the power integer, P, to be described below, and other auxiliary data, 3) one or more blocks of 64 records (23 blocks typical) containing the data proper. The exact number of blocks depends on M. The extra room in the last block is filled with zeros. Most of the information in the headers is not useful for analytic work.

The three header records are encoded as ASCII character information. The encoding of the data records is more complex. Each 256 byte record represents a single time sample of IRAMMP data. The first 16 bytes are a preamble containing a packed BCD representation of the IRIG time code associated with that sample along with BCD codes for sensor head temperature readings and

other similar information. In the remaining 240 bytes are stored 120 sixteen bit integers representing the radiance values associated with the 120 detectors of the IRAMMP sensor. The radiance (watt/sqm/sr) associated with each integer is the integer value multiplied by 10^{-P} , where P the power integer encoded as an ASCII character(s) in the IRAMMP header. P is chosen in such a way as to insure that no integer exceeds 32767. Typically all the integers lie in the range 16384 to 32767.

For detailed information on this format, including the structure of the header records, see ref 2.

The main drawbacks of this format from the standpoint of data visualization software can be seen from this brief review. They are: 1) The image size, M, and the power integer, P, are buried in unconventionally formatted header records, 2) The data records have very non-standard structure due to the 16 byte preamble, 3) The IRIG time codes are comparatively inaccessible because of a non standard encoding using packed BCD.

III. HDF Implementation

The HDF standard is quite flexible. As is usually the case with a flexible standard, specific choices must be made to realize an implementation. Details of the implementation developed for the IRAMMP data are given in the Appendix. This section gives an overview of the design.

In the case of IRAMMP data the most important decision concerned whether to encode the data as integer or floating point numbers. In order to retain the scale factor information, represented by P in the NATO format, it was decided to use floating point numbers which directly represent the radiances in watt/sqm/sr. In HDF this is conveniently done using a structure called a scientific data set (SDS). This choice is less efficient from a storage point of view than the integer alternative, called a Raster image set. Testing, albeit limited, has shown that standard UNIX file compression utilities recover most of the factor of two inefficiency. It was further decided that each image would be stored in a separate SDS. This choice

was not forced because an SDS can store either two or three dimensional data. However, an SDS containing the typical group of 5 to 10 consecutive IRAMMP images would be quite large and unwieldy for all but the most powerful workstation platforms.

It was decided to unpack the time codes and store them as an HDF data structure called a data identifier annotation. This is also not optimal from the storage point of view, but here the increased storage requirement is minimal. The useful information from the NATO format headers is stored in HDF as a file descriptor structure.

IV. NATO to HDF conversion program

A C language program called `nato2hdf` has been written to convert NATO format files to HDF files. This program is designed to run on a workstation running UNIX. The calling sequence is `nato2hdf [options] <inputfile>`. The options are: `-o <outfile name>`; `-p <palfile>`; `-s <start image>`; `-e <end image>`. The `inputfile` is the input file containing the NATO format data. The `outfile` is the output HDF formatted file. The default output file name is `nato.hdf`. The `s` and `e` options are included because a NATO format file can have any number of IRAMMP images. The user of `nato2hdf` can select any contiguous range of these to put into the HDF file. The default is to put all the images in the NATO format file into the HDF file as one image per SDS. The `p` option allows a color pallet to be stored with the data as part of the HDF file. Programs such as `XImage` can store other pallets in the HDF file once it is created. Once started, the program runs autonomously reporting on progress as it proceeds. The `nato2hdf` program is available on request.

V. Public-Domain Software

The HDF utility library and data visualization programs `XImage` and `XDS` are available from NCSA which is located at the University of Illinois, Urbana-Champaign. To use HDF software, access to one of the following is needed: a Sun System 3 or 4 running UNIX, a Silicon Graphics system running UNIX, a VAX

computer running UNIX or VMS, a Macintosh running MacOS, or a IBM compatible PC running DOS. Other workstations running UNIX are also useable with some extra effort. At least 8 MByte of memory is recommended together with a comparable amount of disk space.

To obtain HDF software over the network, access to a computer linked to the Internet and running the ftp file transfer program is required. The procedure is to open an ftp connection to ftp.ncsa.uiuc.edu. On a UNIX platform this is done by issuing the command `ftp ftp.ncsa.uiuc.edu`. The next step is to login using the login name of anonymous and any identifying name as the password. README files on the ftp.ncsa.uiuc.edu machine explain how to obtain the required files using the ftp get command.

The HDF utility library is required by those users wishing to write their own programs to manipulate the data in HDF files. In the case of IRAMMP HDF files, such a user written program is required to get access to the time stamp data stored in the HDF file. The HDF library is constructed such that these user written programs can use either FORTRAN or C as the programming language.

Both the XImage and XDS programs can display the IRAMMP HDF files directly. To use these programs a workstation running some version of the X windowing protocol is required. Since an IRAMMP SDS is a two dimensional image, the XImage program is preferred. In addition to displaying the image, XImage supports a variety of image processing functions such as histogram and profile plot generation. No serious problems with XImage have been encountered in testing with IRAMMP HDF images. The XDS program can be made to work, however undocumented extra steps are required to get it to function using Sun's OpenWindows version of the X protocol. The Spyglass corporation has developed a value added version of XImage called Transform. Transform is available for the Macintosh as well as most UNIX platforms.

APPENDIX

This appendix covers the specific implementation of HDF used by the nato2hdf program. It is intended for experienced users

and should be read in concert with ref 1. The most concise way to describe the contents of a HDF file is to list the types of HDF tags that it contains and the data items to which the tags point. The following table 1 lists the tags created by nato2hdf and the data to which they point

Table 1

Tag	type	IRAMMP data
FID	file identifier	IRAMMP scene number
FD	file descriptor	bytes 1-48 of IRAMMP header + date
IP8	Image Palette	optional user supplied palette
SDS	scientific data set	IRAMMP image (floating point)
DIA	data annotation	IRAMMP time stamps

There is only one FID and FD tag per file. There are as many SDS and DIA tags as there are images in the input NATO file. The palette is present only if the -p option is selected. There are additional tags associated with each SDS. These are the dimensions of the SDS, the labels and the units. The dimensions are 120 and M. The labels are "column", "row" and "radiance". The units are "sample", "detector" and "watt/sqm/sr".

REFERENCES

- 1) NCSA HDF Specifications, Technical report of National Center of Supercomputer Applications at the University of Illinois at Urbana-Champaign, March 1989; NCSA HDF Calling Interfaces and Utilities, Technical report of National Center of Supercomputer Applications at the University of Illinois at Urbana-Champaign, July 1990.
- 2) IRAMMP Data Catalog, QuesTech, Inc., Falls Church VA 22043, Jan 1992.